Optimizing Time-to-Market: A Circular Design Approach for Streamlining New Product Development in Automotive Passenger Vehicle Industries in India

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Abstract

With the substantial growth in Automotive Industry in past few years and with the similar trend of 4 to 8% increase year on year and considering Automotive Mission Plan 2026 of Government of India, there is a huge scope for new product introduction in Automotive Industry. Reducing the overall lead time for these new products will help to gain competitive advantage as well as gaining the market share for Indian Automotive Manufacturers. This will help to boost Indian Economy substantially.

This thesis aims to measure, analyse the current Lead time, identify the gaps and improvement opportunities and finally provide recommendations to reduce the Overall Lead time of New Product Launches in Automotive Industry through working in various areas.

In spite of a lot of research work is conducted to reduce the overall lead time of New Products in Automotive Industry, still there is an average lead time of 24 months because of some unknown reasons and it can be reduced to 16 -18 months. This thesis clearly specifies how organisations can improve Lead time for new Product Launches by identifying the reasons and action planning in the areas of -

- Design Iterations
- Concurrent Engineering
- Effective ECM Implementation
- Structured way of Competency Development of People
- More Focus on Engineer to Order (EOT) Operations
- Streamlining Processes at Supplier
- Quick Response & Zero Defect Manufacturing

Keywords:

New Products Launches, Indian Automotive Industry, Lead Time Reduction, Manufacturing, Supplier, Automobile Industry

Problem Definition

Automotive Mission Plan for 2016-26 is being developed and is a plan developed collectively considering the strategic vision of Indian Government and the Indian Automotive Industry on forecast of Indian Automotive Industry for next 10 years in terms of scope and size, Contribution and share in country's development, global footprints, technological enhancement, skillsets, capabilities and competitiveness.

Indian Automotive Sector will be contributing more than 12% of the country's GDP in next 10 years wherein contribution of Manufacturing Sector is more than 40%. Annual Turnover will be doubled from current INR 7.5L Crores to INR 15L Crores by 2026 as per Ambition Plan to transform India to Global Manufacturing Hub.

This is in line with the Government's objective of growth of Micro, Small & Medium Industries of the country across multiple sectors. This substantial growth of the Indian Automotive Industry will provide a strong push to these sectors as well.

The automotive products are being upgraded considering the change in customer needs, emission & regulation requirements, technology upgradation, increased competition and cost reduction targets. To meet all above requirements and market demand and to achieve this faster growth, it is very important to launch new products into the market at very faster pace.

Research Objective

To understand the issues or reasons for delaying the Product Launches and identify the critical path in order to reduce the same.

Objectives	**KPIs**
Reduce Lead time –Design, Manufacturing & Supplier for New Products Launches in Market	Lead Time – Current Vs Target (Months or %) Error Rate Reduction – Design & Manufacturing (%) Skills development (%)

Priority area of research: Detailed study and analysis of Automotive Industry in Pune and around to understand the reasons of delay.

Study Design & Research Scope: Select Automotive industry based on the current Sales Volumes and New Products and studies the Product Development Cycle in that Industry. Compile the data and the reasons for delay in Product Development cycle in terms of Product & Process Design, Integration of Digital Tools and Mathematical Models, Parts Development, Design Iterations, Management Decisions, Experience and Expertise of People working on New Products.

Research Questions

Following Research Questions are developed for this Thesis -

- What are the current challenges for Indian Automotive Industry to launch New Products on Time?
- What are the various Reasons for delay in Introduction of New Product Programs?
- Can the correlations be established between various reasons for delay?
- Whether enough Research is done in this Area?
- What are the gaps in Research done so far?
- How would this Research help Indian Automotive Industry to gain competitive advantage over their global counterparts?

Review of Literature

As per the details published by Drew Winter(03) on Jun 01, 2003 in WARDSAUTO, to shorten the new product development cycle it is essential to utilize and demonstrate new digital and innovative technologies. There were VR (Virtual Reality) Labs that allows computer generated designs of new automotive products to be viewed as life sized using 3D Technology with use of special glasses. In Virtual reality lab, there is a dark room where an user could “sit” in a virtual enviornemtn that was projected in 3-D around and user could feel the real working environment for Operator. Also, it reflects and demonstrates designer's capability to generate an environment to have real physical feel without prototype build.

As per WARDSAUTO, surprisingly it is revealed by a recent study by the University of Michigan's Center for Automotive Research, in Ann Arbor, MI, people and processes is taking priority over technology in development of product. “It is certainly the case that respondents were more concerned with organizational and human resource approaches to improving high-level design, than with a software-tool oriented technological approach,” says the recent study on Design iterations and process effectiveness at early phase of Product Development cycle.

“At several instances during each interview we made a point of pushing the discussion in the direction of tools. However, the respondents continually came back to organizational themes: layers of management; and, second, populating these new systems with a relatively small number of very experienced people. There was a clear sense that personal expertise was vital and that the key to success was bringing that expertise to bear in an effective manner,” as per David J. Andrea, co-author of this study.

Chris Theodore (04), VP-Advanced Product Creation, Ford Motor Co. says that “If a car's made out of 200 major components and (requires) 200 major processes to put it together; you multiply those two together, that's 40,000 things that you have to do absolutely perfectly from scratch: Your FMEAs (Failure Mode and Effects Analysis), your DVs (design verification), your PVs (production verification), your PFMEAs (Process Failure Mode and Effects Analysis.” He further states that “The research and the effort required to do all those perfectly is huge. If you can cut that in half, if you re-use 60% of the processes and 60% of the components … you get huge improvements. And therefore, you can do a better because your probability of making a mistake is reduced, it’s a big lever”.

This is in line with well-publicized push to so-called Co-Engineering or Simultaneous Engineering, wherein product designers, process engineers, quality engineers and operations teams were supposed to start working together during initial design of product to ensure the robustness and timeliness of development process.

Vivek Deshpande & Afzal H. Alad (05) have focused on studying various tools and techniques for lead time reduction and published a paper in 2014 which focuses on using tools like Design for Production (DEP), Design Structure Matrix (DSM), Work Study Techniques, Lean Tools and Production Planning and Control (PPC). As per study, DFP methods focus on design of product taking into consideration requirements with respect to manufacturing, capacity available and production lead time estimation. If proposed lead time is high, the time can be reduced by applying Circular Design concept of Resdesign. DSM helps in reducing lead time through proper sequencing and prioritisation of development cycle activities. Work study techniques are very much helpful for work simplification, reducing Non Value Activities (NVA) thereby significant reduction in Work Content. Lean manufacturing helps in reduction of all types of wastes to make continuous flow of the work and pull thereby effectively reduction in lead time, operator movement, elimination of non-value-added activity, reduction in inventory and WIP levels in running production line. Production planning and Control is also helpful in reducing lead times.

Paulo Augusto Cauchick Miguel (06) has studied on Product development Modularity which can be helpful to reduce cycle time in product development. In his study, he focused on Modularity in Design and Modularity in Manufacturing. As per him, Modularity in Design help to reduce the design complexity, less design iterations and to perform simultaneous engineering by splitting the product in various modules. In Modular Manufacturing, he

emphasizes on facilitating both Manufacturing and Assembly to meet product variety, production flow, time and cost. This would also help to develop Supplier and Make Vs Buy strategy, improving serviceability and recyclability. In his paper, he concluded that modularity can be considered as a multifaceted concept and its adoption is influential on the entire company to introduce new product within a short span of time.

Kaushik Chaudhary & Sanjay Shah (07) in their paper published in July 2015 on Lead Time reduction using Value Stream Mapping revealed that VSM is one of the best tool to reduce waste in Manufacturing Process by optimising and enhancing value added steps and removing non value added steps. This paper brings in the concept of VSM in more elaborative way and also focuses on application of lean manufacturing Techniques. This paper reveals that the VSM is more effective and efficient when the team physically visit the production process on shop floor, interacts with Operators and observes the process of product being manufactured from start to end. VSM is effective when it is practised in a way that can be known and understood by everyone including operators, the management, suppliers and the customer meaning entire value chain. This will be helpful for the team to discover and understand the real problems from the current process flow, mapping the future state thereby creating a vision of how the process should be through identified improvement actions.

Tawana Jaff and Atanas Ivanov (08) in their research paper on Sustainable Design and Manufacturing published in 2014 throw focus on Manufacturing & Supplier Lead time reduction through Zero Defect Manufacturing. This paper reveals that, nowadays most companies attempt to improve quality management by focusing on Right First Time (RFT) and shortening the time between identifying the defect and manufacturing. They have identified the key methods for reducing Method time and Process Time through required focus on Zero Defect Manufacturing (ZDM). Manufacturing Assessment tool can be leverages to understand problems and opportunities to achieve ZDM which can be done through Manufacturing Survey Questionnaire. Reduction in Lead time towards ZDM can be further studied in consideration of various factors which will provide guidance to industry practitioners.

W. Strandhagen, R. Vallandingham, and Erlend Alfnes have conducted study on optimizing Lean Principles for reduction in lead time through Engineer to Order (ETO) operations in 2018. ETO approach is mostly applicable to companies who are developing and manufacturing highly customized products as per Customer requirements. Bids & Tendering,

Design, Industrialization and program/project management are the key attributes and functional requirements of ETO. In ETO, there is high complexity and iterations which resulted into considerable amount of waste. There is good opportunity and potential to reduce lead time significantly in Design, development and production process. This paper focuses on operationalize lean principles in ETO operations. Also, it emphasizes on adoption of value stream mapping (VSM) approach to investigate various challenges, and opportunities of improvements in the business processes of an ETO company. This paper is helpful to have better understanding in identification of important and critical sources of waste which affect lead time negatively in ETO operations. Specific guidelines and streamlining Lean principles to improve overall lead time through reduction of waste in ETO operations are predominantly highlighted in this paper.

Prashant Tuli and Ravi Shankar (10) have published journal on 30th Oct 2014 on Inclusive, aligned and lean new product development method in a collaborative way through a case study on automotive product design and development. In their study, they focused on studying the collaboration and inclusiveness between buyer and supplier to improve the efficiency and effectiveness of product development process. As per them, early involvement of stakeholders and their valuable inputs during development stage can significantly improve QCD of Product Development by reducing development time and cost and enhanced quality. It focuses on how the lean principles can be applied in inclusive and collaborative environment between an automotive component supplier and the original equipment manufacturer (OEM). There is a comparison of two methodologies/processes of development in this study – generic process and the specified C&L process for developing the same part by a supplier for two different Customers or OEMs. Development for one was done using generic process and the other using the specific C&L process. The study focuses on detail analysis of various phases of value stream mapping and highlights the contribution of a combined C&L approach in reducing NVAs, cycle time and overall efforts during Product Development cycle.

José-Mauricio Galli Geleilate, Stav Fainshmidt and Maurizio Zollo(11) have published a paper on 9th August 2020 to throw light on a different perspective in new Product Development. Their study is based on correlation between quantum of problems with number of New Products. They have put forward a new and interesting finding which states that Organisational capability is the key driver for competitive advantage in New Product Development. They focused on engaging specific internal as well as external factors which

are significant for improving know how to coordinate and drive systemic change. Also, they emphasise specific focus on clear distribution between internal and external errors, which reveals that with increased New Products developments, internal voluntary investigations should throw light on internal manufacturing defects, while suppliers focus on mitigating outsourced parts defects. This study brings in key priority on improving the capability of employees and organization which can be helpful to accelerate the process of New Product Introduction.

Rajan Suri and John Burke (12) published a book on 29th October 2020 on Quick Response Manufacturing which emphasizes on companywide approach in reducing lead time. Quick Response Manufacturing (QRM) is fundamentally based on Operations Research Technique to focus on single target with the goal of reducing lead times. QRM is distinguished from other time-based programs in terms of covering an entire organization from top to bottom which includes Top Management, Sales, Design, Process, Quality, Supply Chain Management and Production Teams. This book give more focus on kaizen, TQM, TPM, and other manufacturing excellence processes for streamlining activities in entire value chain as a part of QRM. Rethink on product material and production management are the major emphasises of this study to introduce new product quickly. This book shows the importance of streamlining manufacturing processes to reduce the overall lead time of New Product Introduction.

G Schuh, P. Prote,M. Luckert, F. Basse, V. Thomson, W. Mazurek (13) published a paper on Adaptive Design of Engineering Change Management in Highly Iterative Product Development in 2018 which focuses on importance of effective Engineering Change Management in New Product Development. As product progresses from early development phase to serial production, the effective ECM process brings in high agility and flexibility to suit the customer as well as product requirements. An effective ECM process is always helpful to adapt this requirement smoothly. This study is effective in creating the process for the continuous adaption of ECM using the concept of complexity management to meet these additional, time-dynamic requirements. The findings are evaluated and integrated into structured complexity-oriented models. A method is established that triggers the design of ECM in such a way that the time-variable management requirements across the product lifecycle are addressed. This research work has put forward very important point of effective change management and its impact on reducing Design iterations thereby reducing overall lead time in new product introduction.

Circular Design Thinking in Automotive Design: Studies by Bridgens et al. (2019) emphasize the need for a fundamental shift in product design strategy. Circular product design in the automotive industry involves strategies such as disassembly and reassembly design, promoting long-lasting products and product-life extension. These practices contribute to circularity and minimize environmental impact. Circular design thinking involves reevaluating product design to align with circular principles, considering the entire life cycle of a product (Bocken et al., 2016). It encourages designers to create products with intentional options for end-of-life strategies, promoting circularity and minimizing waste thereby reducing the duration of New Product Development Cycle.

Research Gap

After thoroughly reviewing journals and other articles as well as information available in various abstracts, it is found that a lot of research has been done in reduction of lead time in introduction of new products in Automotive Industry in the areas of Design, Manufacturing, and Supply Management etc.

In WARDSAUTO, though Drew Winter had put on good focus on use of new digital technology to reduce the lead time in NPD, there is significant requirement of integration and smooth data flow between different digital systems. All these Virtual tools need to be extensively used through capability development of people using it. Also, there is a need to have more research on implementing concurrent engineering where product designers, process developers and manufacturing teams are supposed to work together during the initial design to speed up the overall product development process.

Also, as explained earlier, ETO environment is having large complexity to meet customer requirement and effective ECM can be leveraged to optimise product lead times in such environment. With Industry 4.0 and other digital technology in manufacturing sector, the further research can be done on usage of these technologies to reduce the waste in case of ETO. This can also be helpful to evaluate efficiency and productivity need in the next-generation ETO operations and ways to develop the same.

One of the important attribute in overall development of New Products and lead time optimisation is improving the capability of people in the organization on Technical Skill Set. This is the area wherein Human Resource Department can focus on development of skills and technical competency through Dexterity Labs and providing more hands-on learning opportunities.

Moreover, there is an opportunity to do more research work on Quick Response Manufacturing through streamlining new product introduction process across various functions of organization. Also, extensive work needs to be done ECM effectiveness through complexity management at Design stage to reduce overall lead time.

Also, Integration of Circular Design with New Products Development Lead time is a comparatively less explored area and more research opportunities are available.

Research Methodology

- Library Research
    - Analysis of historical records, documents or data related to new product launches manufacturing lead time for last 05 years
- Field Research
    - Mail Questionnaire
    - Mass Observation
    - Personal/Focused Interviews
    - Group Interview
    - Case Studies
- Laboratory/Virtual Research
    - Analysis of Virtual Tools
    - Assessment of Skill/dexterity levels of people working on New Product Development

Based on the above, research methods will be divided into 03 groups-

Group 1 – To use where the data already available is not sufficient to arrive at the required solutions. For example – Let us assume that Lead time for launching a new product into the market is 24 months currently.

Group 2 – To establish the relationship between the data and unknowns using statistical techniques. For example – Lead time of 24 months is due to some unknown reasons beyond the data collected through various research methods.

Group 3 – To evaluate the accuracy of the result obtained. For examples – Based on the data collected a correlation need to be established for delay in new product launches for various parameters such as –

- Design Iterations & Changes
- Virtual Manufacturing/E Builds
- In-house Process Readiness
- Supplier Process Readiness
- People Skills and Competencies
- Impact of Circular Economy on New Product Development Cycle

An Exploratory study through Qualitative and Quantitative Analysis will be conducted for the population of @ 450 nos. through stratified random sampling method for sample size of @ 70 nos. in various Automotive Industries in and around Pune, Maharashtra.

Tentative Chapter Plan

Chapter 1: Introduction and Thesis Overview

Chapter 2: Review of Literature

Chapter 3: Research Methodology & Gap Identification

Chapter 4: Data Gathering, Analysis and Presentation

Chapter 5: Conclusion and Future Recommendations

Bibliography

Annexure

Visible Research Outputs

Identification of actions to reduce overall lead time in New Product Launches in Automotive Industry through working in areas of -

- Design Iterations
- Concurrent Engineering
- Effective ECM Implementation
- Structured way of Competency Development of People
- More Focus on Engineer to Order (EOT) Operations
- Streamlining Processes at Supplier
- Quick Response & Zero Defect Manufacturing
- Integration of Circular Economy Framework

Final research output will be the achievement of following Objectives through measurable Key Performance Indicators (KPIs)

Objectives	**KPIs**
Reduce Lead time –Design, Manufacturing & Supplier for New Products Launches in Market	Lead Time – Current Vs Target (Months or %) Error Rate Reduction – Design & Manufacturing (%) Skills development (%)

Future Plans

Year 1: Course Work, Introduction and Thesis Overview

Year 2: Literature Review, Data Gathering

Year 3: Data Compilation, Presentation and Analysis, Development of Model, Finalization and writing the Thesis

Year → / Activity ↓	1st		2nd		3rd	
Course Work						
Introduction and Overview of Thesis						
Literature Review						
Data Gathering						
Data Compilation, Analysis and Presentation						
Development of Model						
Finalisation and Writing the Thesis						

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Signature of Student **Signature of Supervisor and Co-Supervisor(s)**